

Soil Organic Carbon Sequestration and Agricultural Greenhouse Gas Emission in the Southeastern USA

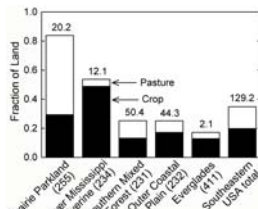


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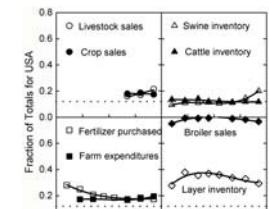
Characteristics of the Southeastern USA



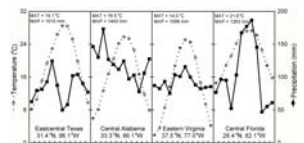
Delineation of the southeastern USA into 5 provinces from Bailey (1995). See figure to right for names of provinces.



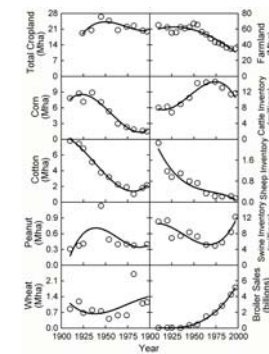
Fraction of land in crops and pasture. Value above bar represents total land area (Mha). Data from USDA-NASS (1997).



Fraction of production characteristics in the USA derived from 11 states in the region (AL, AR, DE, FL, GA, LA, MD, MS, NC, SC, VA). Dotted line represents equivalent land area of the 11 states as a fraction of total for USA. Data from USDA-NASS.



Mean monthly temperature and precipitation at 4 locations in the region. Data from National Climatic Data Center.



Production characteristics of selected crops and livestock during the past century for 11 states in the region (see above). Data from USDA-NASS.

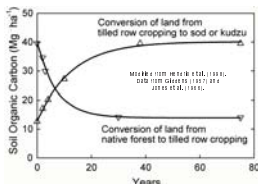


Soil organic C to a depth of 1 m in the southeastern USA (USDA-NRCS, 1997).

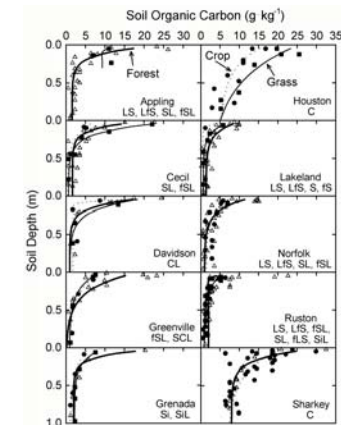
Mean annual precipitation, temperature, and ratio of precipitation-to-potential evapotranspiration (P/PET). Data from National Climatic Data Center at locations on a 1° grid. PET based on Thornthwaite equation.

Agricultural Management to Mitigate Greenhouse Gas Emission through Soil Organic C Sequestration

Land Use



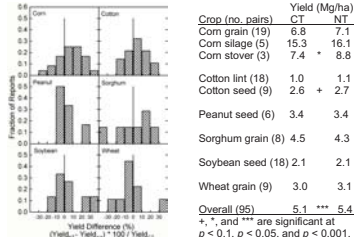
Soil disturbance of native vegetation causes rapid and extensive loss of soil organic C in the region due to the relatively warm and moist climatic condition that is conducive for decomposition. Loss of soil organic C with water erosion is also serious when soil is exposed to high-intensity rainfall. Reestablishment of perennial vegetation sequestered soil organic C at 75% of the rate of loss.



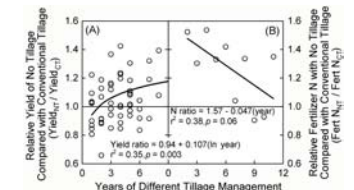
Organic C distribution in soils typical of the southeastern USA is affected by land use. Except for high-clay soils, soil organic C is typically <5 g/kg below 0.5 m depth. Data in figure from McCracken (1959). From a compilation of studies, soil organic C content varied as follows: forest (45 Mg/ha) = grass (41 Mg/ha) > crop (28 Mg/ha). The change from forest to grass caused a loss of soil organic C of 8 ± 35%, while the change from forest to crop caused a loss of 36 ± 29%.

Once stable vegetative cover is disturbed by cultivation, soil organic C (SOC) declines. Grass management systems may have as large a potential to sequester SOC as forest systems.

Conservation-Tillage Cropping



Crop yield (and C fixation with subsequent input to soil) has been both positively and negatively affected by tillage in the region. On average, crop yield was greater under no tillage (NT) than under conventional tillage (CT). Crop yield likely benefits from water conservation of surface-placed crop residues with NT, even in this humid climatic region.



Relative yield (Panel A) increased logarithmically with time from a starting point of 0.94, which was not significantly different from unity. Fertilizer N required to achieve 95% of maximum sorghum grain yield (Panel B) was 60% greater with NT than with CT initially, but became similar with time. These results suggest that accumulation of soil organic matter (both total C and N) under NT sufficiently alters the soil environment to become more productive, although at an initial expense of fertilizer to feed both plants and the reserve of nutrients required in an expanding organic matter pool.

Property	Cover Crop	Without	With
Duration of comparison (yr)	12	**	9
SOC sequestration with NT (Mg/ha)	2.5	**	3.9
SOC sequestration with NT (Mg/ha/yr)	0.28	**	0.53
Ratio of SOC _{NT} : SOC _{CT}	1.11	*	1.20

No tillage with cover cropping in the southeastern USA adds C to the soil through above- and below-ground cover crop production, but also may limit decomposition of organic matter in soil, which is dried during cover crop growth. These data exemplify the benefit of cover cropping on soil quality.

Conservation tillage is an appropriate technology for the southeastern USA. Long-term implementation will have the greatest effect on increasing (1) crop productivity, (2) N fertilizer use efficiency, and (3) soil organic C sequestration. Cover crops are needed with NT to maximize benefits. Studies are needed to quantify N₂O emission and CH₄ uptake under NT in the region.

Pastures

Effect of grass establishment	
Duration of comparison (yr)	15 ± 17
SOC sequestration (Mg/ha/yr)	1.03 ± 0.90

Mean rate of SOC sequestration with grass establishment in the limited number of studies (n = 12) was 2.5 times greater than with NT cropping.

Effect of harvest management	
Hayed	
15-19-yr-old bermudagrass	31.2 ± 5.4
5-yr-old bermudagrass	38.1 ± 2.4
SOC sequestration (Mg/ha/yr)	0.76 ± 0.60

Greater SOC sequestration with grazing than with haying was likely due to the return of processed forage back to the soil via feces rather than removed from the field via hay. It might be that overgrazed pastures have lower SOC than well-managed pastures, but data to support this effect are not available.

Effect of manure application	
Without	
2-yr studies (n=6)	19.8 ± 9.9
11 + 8-yr studies (n=8)	30.6 ± 11.4
SOC sequestration for all (Mg/ha/yr)	0.26 ± 2.15
SOC sequestration for >2-yr studies	0.72 ± 0.67

Conversion of C contained in poultry litter to SOC was 17 ± 15%. There is a need for more long-term studies with manure application, since 2-year studies do not offer great sensitivity to detect changes in SOC.

Trace-Gas Emission

Nitrous oxide (N₂O)
There have been very few studies conducted in the southeastern USA on nitrous oxide (N₂O) emission from crop or pasture land.

Methane (CH₄)
Ruminant livestock are a significant source of agricultural methane (CH₄) production via enteric fermentation. USDA (2004) estimated that enteric fermentation represented ca. 70% of total CH₄ emission from agricultural sources in the USA. The literature suggests CH₄ emission of 0.15 ± 0.08 kg CH₄/head/d. With nearly 19 Mha of pasture land in the region supporting 12 million head of cattle, the average cattle density in the region would be 0.62 head/ha. Therefore, CH₄ emitted from grazing cattle could be calculated as 34 kg CH₄/ha/yr. With global warming potential of CH₄ 21 times greater than that of CO₂, CH₄ emission from grazing cattle might contribute an atmospheric forcing of 0.37 to 1.20 Mg CO₂-C equivalent/ha/yr (lower and upper end of mean ± one standard deviation).

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Although some data are available, much more effort is needed to determine the effects of pasture management on soil organic C and greenhouse gas emission in the region.